

# Forensic Spectroscopy in the High School Laboratory

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- **Forensics of LEDs (Spectra of light emitting diodes)**

A crime has occurred and a broken LED flashlight is found at the scene. Crime Scene Investigators need to determine the manufacturer of the flashlight.

Using spectra of LEDs from known distributors, determine which company made the LEDs from the crime scene the flashlight.

- **Poison Analysis using Absorption Spectroscopy**

Using Absorbance Spectroscopy, compare the spectrum of the “poison mixture” sample to those of the suspected components. Determine the composition of the poison.

## **Exploring Spectra**

- **Emission Spectra**

- Spectrum Tubes
- Flame Test
- LEDs
- Flashlights
- Compact Fluorescent Tubes
- Light Sticks

- **Absorption Spectra**

- Colored Solutions
- Beer’s Law

- **Reflection**

- Off surfaces
- Off metals
- Various light sources

Free files from Vernier: <http://www.vernier.com/spectroscopy/svis.html>

# Visible Spectra of Commercial Dyes

Light is composed of photons with quantized wavelengths and energies. The longer the wavelength, the lower the energy. Types of light are categorized as: gamma, x-ray, ultraviolet (UV), visible (vis), infrared (IR), microwave, and radio wave, depending on the wavelength of the photon. The light that our eyes can detect, conveniently referred to as the visible region, is a very small section of the light spectrum.

Spectrophotometry is the study of the transmission or absorbance of light through a substance. Transmittance is a measure of the amount of light passing through a substance; absorbance is the amount of light that was captured by a substance. A clear colorless piece of glass has close to 100% transmittance and 0 absorbance of visible light. In colored liquids, for example, the color we see is a result of the different wavelengths and total amount of light that the liquid absorbed. In this experiment, you will use a Vernier Spectrometer or SpectroVis to identify the dyes found in commercial products. Different dyes absorb at different wavelengths. You will measure the absorbance of food dyes, mixed with water, over the 380 – 950 nm range and compare the spectra of the dyes to the spectra of various commercial products.

## OBJECTIVES

In this experiment, you will

- Measure and analyze the visible light absorbance spectrum of various samples of aqueous food dye mixtures to determine the absorbance spectrum for each sample.
- Compare and contrast the spectra of various food dye mixtures.
- Measure a sample of a commercial liquid product and identify the food dyes used to color the product.

## MATERIALS

Vernier Spectrometer or SpectroVis  
LabQuest  
one cuvette  
250 mL beakers for food dyes samples  
100 mL graduated cylinder  
plastic Beral pipets

food dyes  
commercial drink or mouthwash  
distilled water  
stirring rod  
tissues (preferably lint-free)

## **PROCEDURE**

1. Obtain and wear goggles.
2. Use a USB cable to connect a Vernier Spectrometer or SpectroVis to a LabQuest. Turn on the LabQuest.
3. Record the type of food dyes that you will be testing (such as Red #40, Blue #1, Yellow #5). Prepare each sample by dissolving 2 drops of a food dye in 100 mL of distilled water.
4. Calibrate the Spectrometer.
  - a. Prepare a *blank* by filling an empty cuvette  $\frac{3}{4}$  full with distilled water.
  - b. Tap the reddish-orange meter box and select Calibrate. The following message appears in the Calibrate dialog box: “Waiting ... seconds for lamp to warm up.” After the allotted time, the message changes to: “Finish Calibration”.
  - c. Place the blank in the spectrometer; make sure to align the cuvette so that the clear sides are facing the light source of the spectrometer. Select “Finish Calibration”. When the message “Calibration Completed” appears, after several seconds, select OK.
5. Conduct a full spectrum analysis of a food dye sample.
  - a. Empty the blank cuvette and rinse it twice with small amounts of a food dye mixture. Fill the cuvette  $\frac{3}{4}$  full with the food dye mixture and place it in the spectrometer. Align the cuvette so that the clear sides are facing the light source of the spectrometer.
  - b. Start the data collection. A full spectrum graph of the food colored solution will be displayed. Tap Stop to complete the analysis.
  - c. Examine the graph, noting the peak or peaks of very high absorbance or other distinguishing features. Save and/or print a copy of the graph.
6. To save your data, tap the file cabinet icon next to Run 1.
7. Repeat Steps 5 and 6 with the remaining food dye samples.
8. Obtain a sample of a commercial product containing a dye, such as a mouthwash or beverage. Repeat Step 5 with the commercial product.

**DATA TABLE**

Trial	Food Dye (or product)	Peaks or unique features of the spectrum
1		
2		
3		
4		

**DATA ANALYSIS**

1. Describe, in detail, the spectrum of each food dye sample. Emphasize the features of each spectrum that distinguishes it from the other food dyes.
  
2. Identify the wavelengths and absorbance values of every peak in the graph of each food dye.
  
3. Identify the food dye or dyes present in the commercial product that you tested. Support your identification with specific information from your testing.

# Emission Spectra

In this experiment, you will use a Vernier Spectrometer or a Vernier SpectroVis to measure the light emitted by selected sources. These sources can be, but are not limited to, discharge tubes, LEDs, lamps, or luminescent or fluorescent liquid solutions.

The electrons of atoms and molecules exist in specific energy states. The energy emitted by the excitation of electrons is limited to differences between these states, thus specific energies of light are emitted. The color of a glowing LED, for example, is determined by the energy of the emitted light. The energy and wavelength of the light is described by the equation  $E = hc/\lambda$ , where  $\lambda$  is the wavelength,  $h$  is Planck's constant ( $6.63 \times 10^{-34}$  J sec), and  $c$  is the speed of light ( $3.00 \times 10^8$  m/sec). If you are measuring the emission spectrum of a gas trapped in a discharge tube, only certain wavelengths of light are emitted by the gas and the "pattern" that is produced is unique for that substance.

## OBJECTIVES

In this experiment, you will

- Practice measuring the emission spectrum of a source of light.
- Compare and contrast the spectra of various light sources.

## MATERIALS

Vernier Spectrometer, w/o light source/ cuvette holder attachment, <i>or</i>	light sources: LEDs
Vernier SpectroVis with Optical Fiber	discharge tubes
LabQuest	lamp or flashlight

## PROCEDURE

1. Use a USB cable to connect a spectrometer to your LabQuest. Connect a SpectroVis Optical Fiber to the cuvette holder of the SpectroVis, *or* connect a fiber optic cable to the threaded detector housing of the Vernier Spectrometer.
2. Turn on the LabQuest.
3. In your data table, record the type of light source that you will be testing.
4. To prepare the spectrometer for measuring light emissions, open the Sensors menu and choose Change Units ► USB: Spectrometer ► Intensity.
5. On the Meter screen, tap Mode. On the Data Collection screen, change the Sample Time to 80 ms and change the Samples to Average to 1.

6. Measure the emission spectrum of a light source.
  - a. Aim the tip of the fiber optic cable at the light source.
  - b. Start the data collection. An emission spectrum will be graphed.
  - c. Move the light source toward or away from the detector so that the peak emission is less than 1. When you achieve a satisfactory graph, stop the data collection. Write down your observations of the emission spectrum in your data table.
  - d. If the emission values are very small, stop the data collection, repeat Step 5, and this time change the Sample Time to 100 ms (the maximum allowable for the LabQuest).
7. To save your graph, tap the file cabinet icon next to Run 1.
8. Repeat Step 6 with another light source.
9. To save your data as a file, choose Save from the File menu. Tap the keyboard icon at the bottom of the screen and use the keyboard to name your new file. Select Save.

## DATA TABLE

Trial	Light Source	Peaks or unique features of the spectrum
1		
2		
3		

## DATA ANALYSIS

1. Describe, in detail, the emission spectrum of each light source. Emphasize the features of each spectrum that distinguishes it from the other light sources that you tested.
2. Identify the wavelengths of every peak in the graph of each light source.
3. Speculate about how the emission spectrum below might have been produced.

